

## Features

- Single 5 volt supply
- Programmable  $\mu$ -law/A-law Codec and filters
- Fully differential output driver
- SSI digital interface
- SSI speed control via external pins CSLO-CSL2
- Individual transmit and receive mute controls
- 0dB gain in receive path
- 6dB gain in transmit path
- Low power operation
- ITU-T G.714 compliant

## Applications

- Cellular radio sets
- Local area communications stations
- Line cards

DS5178

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### Ordering Information

MT9162AE	20 Pin Plastic DIP (300 mil)
MT9162AS	20 Pin SOIC
MT9162AN	20 Pin SSOP

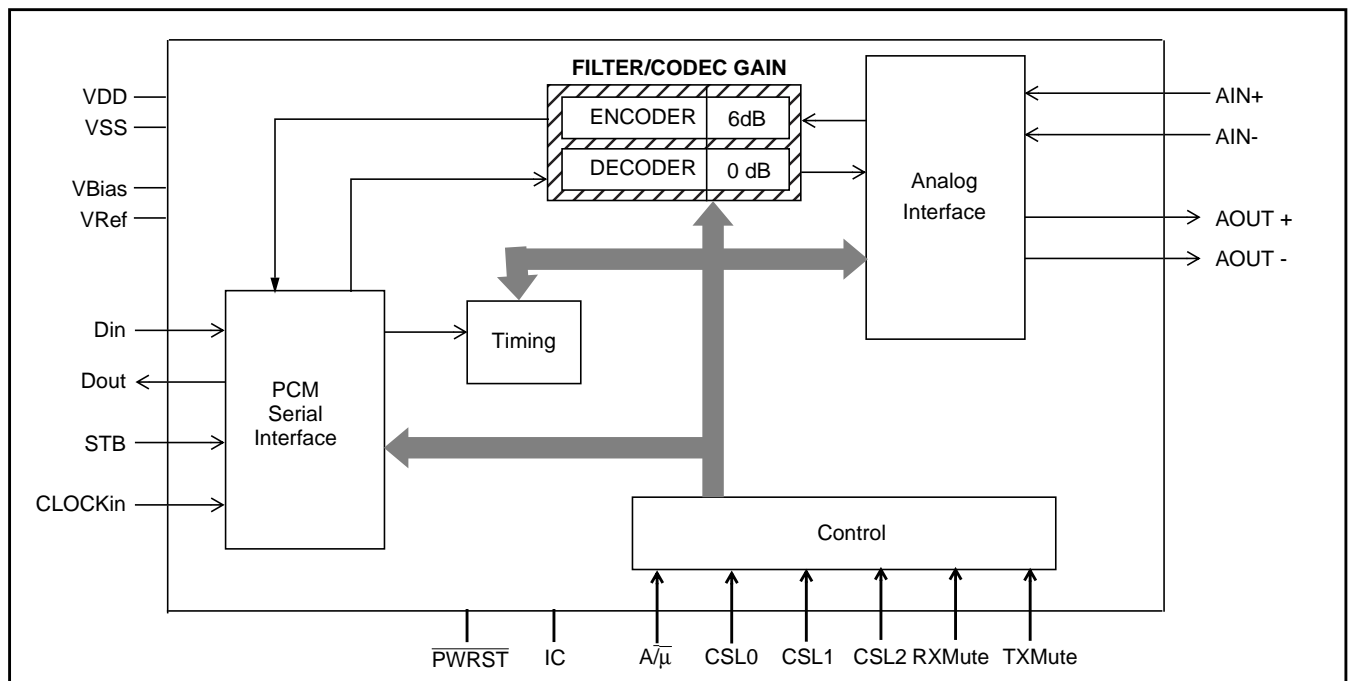
**-40°C to +85°C**

## Description

The MT9162 5V single rail Codec incorporates a built-in Filter/Codec, transmit anti-alias filter, a reference voltage and bias source. The device supports both A-law and  $\mu$ -law requirements.

The analog interface is capable of driving a 20k ohm load.

The MT9162 is fabricated in Mitel's ISO<sup>2</sup>-CMOS technology ensuring low power consumption and high reliability.



**Figure 1 - Functional Block Diagram**

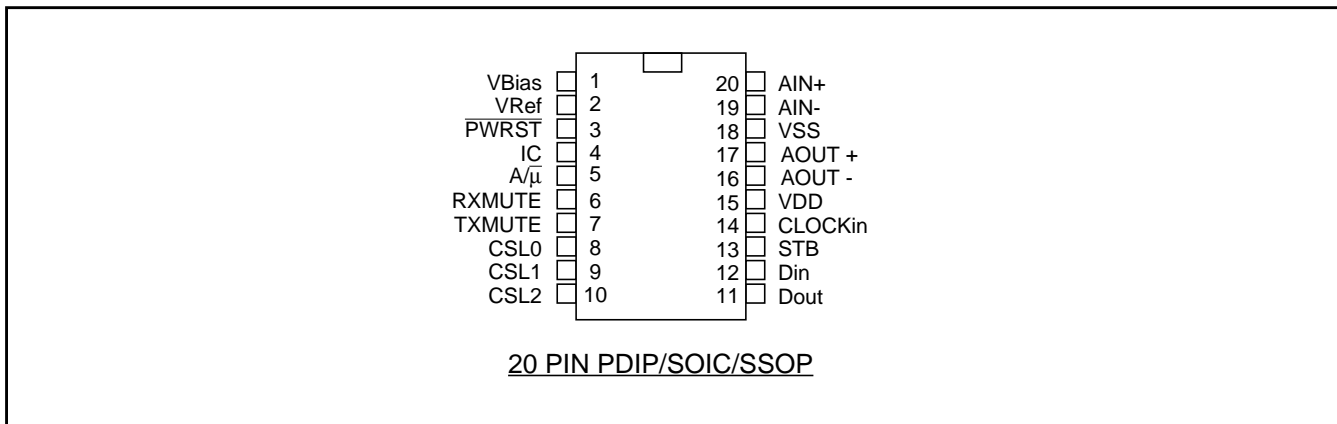


Figure 2 - Pin Connections

## Pin Description

Pin #	Name	Description
1	V <sub>Bias</sub>	<b>Bias Voltage (Output).</b> (V <sub>DD</sub> /2) volts is available at this pin for biasing external amplifiers. Connect 0.1 μ F capacitor to V <sub>SS</sub> . Connect 1 μF capacitor to Vref.
2	V <sub>Ref</sub>	<b>Reference Voltage for Codec (Output).</b> Nominally [(V <sub>DD</sub> /2)-1.9] volts. Used internally. Connect 0.1 μ F capacitor to V <sub>SS</sub> . Connect 1 μF capacitor to VBias
3	PWRST	<b>Power-up Reset.</b> Resets internal state of device via Schmitt Trigger input (active low).
4	IC	<b>Internal Connection.</b> Tie externally to V <sub>SS</sub> for normal operation.
5	A/μ	<b>A/μ Law Selection.</b> CMOS level compatible input pin governs the companding law used by the device. A-law selected when pin tied to V <sub>DD</sub> or μ-law selected when pin tied to V <sub>SS</sub> .
6	RXMute	<b>Receive Mute.</b> When 1, the transmit PCM is forced to negative zero code. When 0, normal operation. CMOS level compatible.
7	TXMute	<b>Transmit Mute.</b> When 1, the transmit PCM is forced to negative zero code. When 0, normal operation. CMOS level compatible.
8	CSL0	<b>Clock Speed Select.</b> These pins are used to program the speed of the SSI mode as well as the conversion rate between the externally supplied MCL clock and the 512 kHz clock required by the filter/codec. Refer to Table 2 for details. CMOS level compatible.
9	CSL1	
10	CSL2	
11	D <sub>out</sub>	<b>Data Output.</b> A tri-state digital output for 8-bit wide channel data being sent to the Layer 1 device. Data is shifted out via the pin concurrent with the rising edge of BCL during the timeslot defined by STB.
12	D <sub>in</sub>	<b>Data Input.</b> A digital input for 8-bit wide data from the layer 1 device. Data is sampled on the falling edge of BCL during the timeslot defined by STB. CMOS level compatible.
13	STB	<b>Data Strobe.</b> This input determines the 8-bit timeslot used by the device for both transmit and receive data. This active high signal has a repetition rate of 8 kHz. CMOS level compatible.
14	CLOCKin	<b>Clock (Input).</b> The clock provided to this input pin is used by the internal device functions. Connect bit clock to this pin when it is 512 kHz or greater. Connect a 4096 kHz clock to this pin when the bit clock is 128 kHz or 256 kHz. CMOS level compatible.
15	V <sub>DD</sub>	<b>Positive Power Supply.</b> Nominally 5 volts.
16	AOUT-	<b>Inverting Analog Output.</b> (balanced).
17	AOUT+	<b>Non-Inverting Analog Output.</b> (balanced).
18	V <sub>SS</sub>	<b>Ground.</b> Nominally 0 volts.
19	Ain-	<b>Inverting Analog Input.</b> No external anti-aliasing is required.
20	Ain+	<b>Non-Inverting Analog Input.</b> Non-inverting input. No external anti-aliasing is required.

## Overview

The 5V single rail Codec features complete Analog/Digital and Digital/Analog conversion of audio signals (Filter/Codec) and an analog interface to a standard analog transmitter and receiver (Analog Interface). The receiver amplifier is capable of driving a 20k ohm load.

## Functional Description

### Filter/Codec

The Filter/Codec block implements conversion of the analog 0-3.3 kHz speech signals to/from the digital domain compatible with 64 kb/s PCM B-Channels. Selection of companding curves and digital code assignment are programmable. These are ITU-T G.711 A-law or  $\mu$ -Law, with true-sign/Alternate Digit Inversion.

The Filter/Codec block also implements a transmit audio path gain in the analog domain. Figure 3 depicts the nominal half-channel for the MT9162.

The internal architecture is fully differential to provide the best possible noise rejection as well as to allow a wide dynamic range from a single 5 volt supply design. This fully differential architecture is continued into the analog interface section to provide full chip realization of these capabilities for the external functions.

A reference voltage ( $V_{Ref}$ ), for the conversion requirements of the Codec section, and a bias voltage ( $V_{Bias}$ ), for biasing the internal analog sections, are both generated on-chip.  $V_{Bias}$  is also brought to an external pin so that it may be used for biasing external gain setting amplifiers. A 0.1 $\mu$ F capacitor must be connected from  $V_{Bias}$  to analog ground at all times. Likewise, although  $V_{Ref}$  may only be used internally, a 0.1 $\mu$ F capacitor from the  $V_{Ref}$  pin to ground is required at all times. The analog ground reference point for these two capacitors must be physically the same point. To facilitate this the  $V_{Ref}$  and  $V_{Bias}$  pins are situated on adjacent pins.

The transmit filter is designed to meet ITU-T G.714 specifications. An anti-aliasing filter is included. This is a second order lowpass implementation with a corner frequency at 25 kHz.

The receive filter is designed to meet ITU-T G.714 specifications. Filter response is peaked to compensate for the  $\sin x/x$  attenuation caused by the 8 kHz sampling rate.

Companding law selection for the Filter/Codec is provided by the  $A/\bar{\mu}$  companding control pin. Table 1 illustrates these choices.

Code	ITU-T (G.711)	
	$\mu$ -Law	A-Law
+ Full Scale	1000 0000	1010 1010
+ Zero	1111 1111	1101 0101
-Zero (quiet code)	0111 1111	0101 0101
- Full Scale	0000 0000	0010 1010

Table 1: Law Selection

### Analog Interfaces

Standard interfaces are provided by the MT9162. These are:

- The analog inputs (transmitter), pins AIN+/AIN-. The maximum peak to peak input is 3.667Vpp  $\mu$ -law and across AIN+/AIN- 3.8Vpp A-law.
- The analog outputs (receiver), pins AOUT+/AOUT-. This internally compensated fully differential output driver is capable of driving a load of 20k ohms.

### PCM Serial Interface

A serial link is required to transport data between the MT9162 and an external digital transmission device. The MT9162 utilizes the strobed data interface found on many standard Codec devices. This interface is commonly referred to as Simple Serial Interface (SSI).

The required mode of operation is selected via the CSL2-0 control pins. See Table 2 for selections based in CSL2-0 pin settings.

### Quiet Code

The PCM serial port can be made to send quiet code to the decoder and receive filter path by setting the RxMute pin high. Likewise, the PCM serial port will send quiet code in the transmit path when the

CSL <sub>2</sub>	CSL <sub>1</sub>	CSL <sub>0</sub>	External Clock Bit Rate (kHz)	CLOCKin (kHz)
1	0	0	128	4096
1	0	1	256	4096
0	0	0	512	512
0	0	1	1536	1536
0	1	0	2048	2048
0	1	1	4096	4096

**Table 2: Bit Clock Rate Selection**

TxMute pin is high. When either of these pins are low their respective paths function normally. The -Zero entry of Table 1 is used for the quiet code definition.

**SSI Mode**

The SSI BUS consists of input and output serial data streams named Din and Dout respectively, a Clock input signal (CLOCKin), and a framing strobe input (STB). A 4.096 MHz master clock is also required for SSI operation if the bit clock is less than 512 kHz.

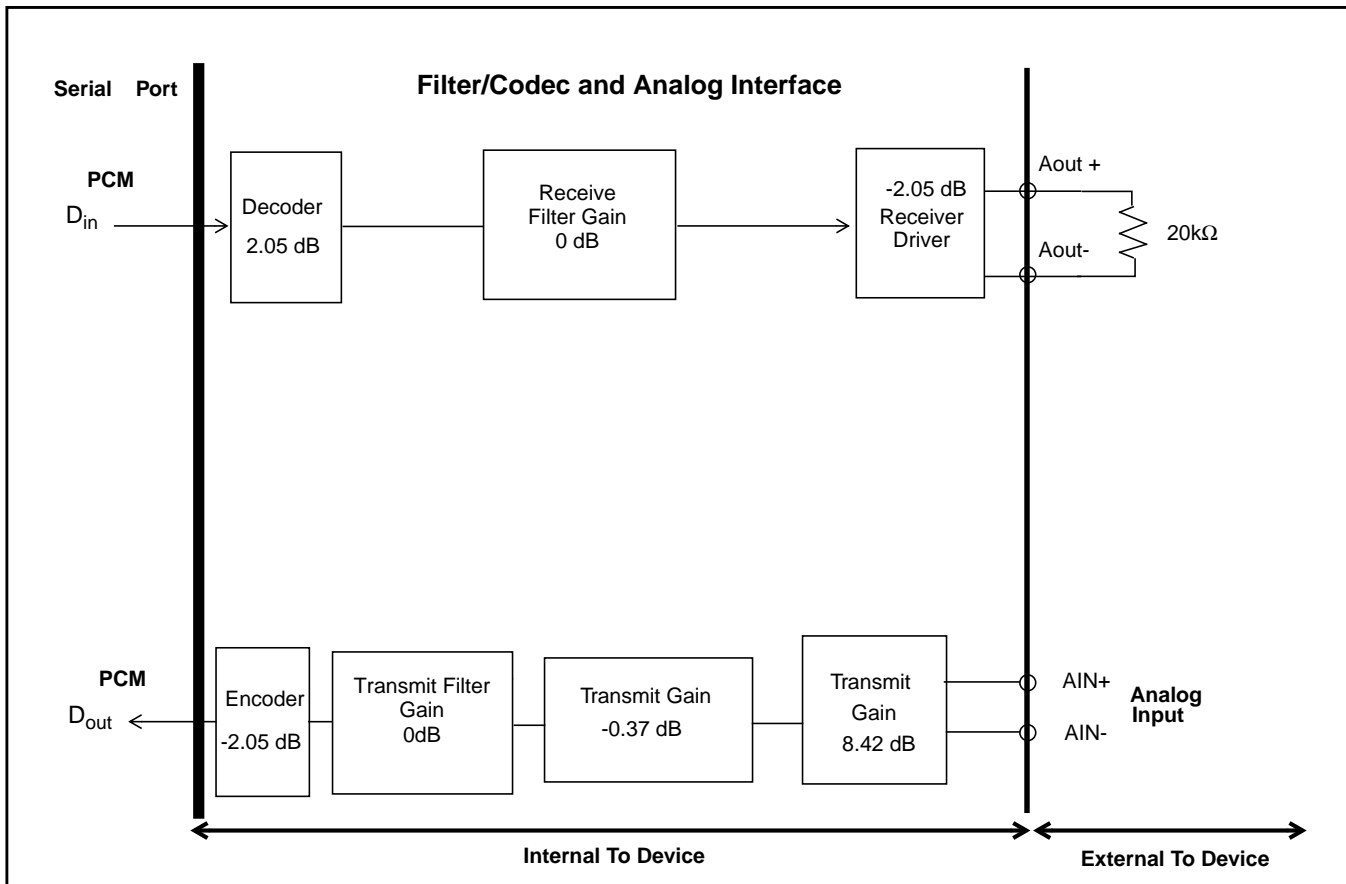
The timing requirements for SSI are shown in Figures 5 & 6.

In SSI mode the MT9162 supports only B-Channel operation. Hence, in SSI mode transmit and receive B-Channel data are always in the channel defined by the STB input.

The data strobe input STB determines the 8-bit timeslot used by the device for both transmit and receive data. This is an active high signal with an 8 kHz repetition rate.

SSI operation is separated into two categories based upon the data rate of the available bit clock. If the bit clock is 512 kHz or greater then it is used directly by the internal MT9162 functions allowing synchronous operation. If the available bit clock is 128 kHz or 256 kHz, then a 4096 kHz master clock is required to derive clocks for the internal MT9162 functions.

Applications where Bit Clock (BCL) is below 512 kHz are designated as asynchronous. The MT9162 will re-align its internal clocks to allow operation when the external master and bit clocks are asynchronous. Control pins CSL2, CSL1 and CSL0 are used to program the bit rates.



**Figure 3 - Audio Gain Partitioning**

For synchronous operation, data is sampled from Din, on the falling edge of BCL during the time slot defined by the STB input. Data is made available, on Dout, on the rising edge of BCL during the time slot defined by the STB input. Dout is tri-stated at all times when STB is not true. If STB is valid, then quiet code will be transmitted on Dout during the valid strobe period. There is no frame delay through the PCM serial circuit for synchronous operation.

For asynchronous operation Dout and Din are as defined for synchronous operation except that the allowed output jitter on Dout is larger. This is due to the resynchronization circuitry activity and will not affect operation since the bit cell period at 128 kb/s and 256 kb/s is relatively large. There is a one frame delay through the PCM serial circuit for asynchronous operation. Refer to the specifications of Figures 5 & 6 for both synchronous and asynchronous SSI timing.

**Applications**

Figure 4 shows the MT9162 in a line card application.

**PWRST**

While the MT9162 is held in  $\overline{\text{PWRST}}$  no device control or functionality is possible.

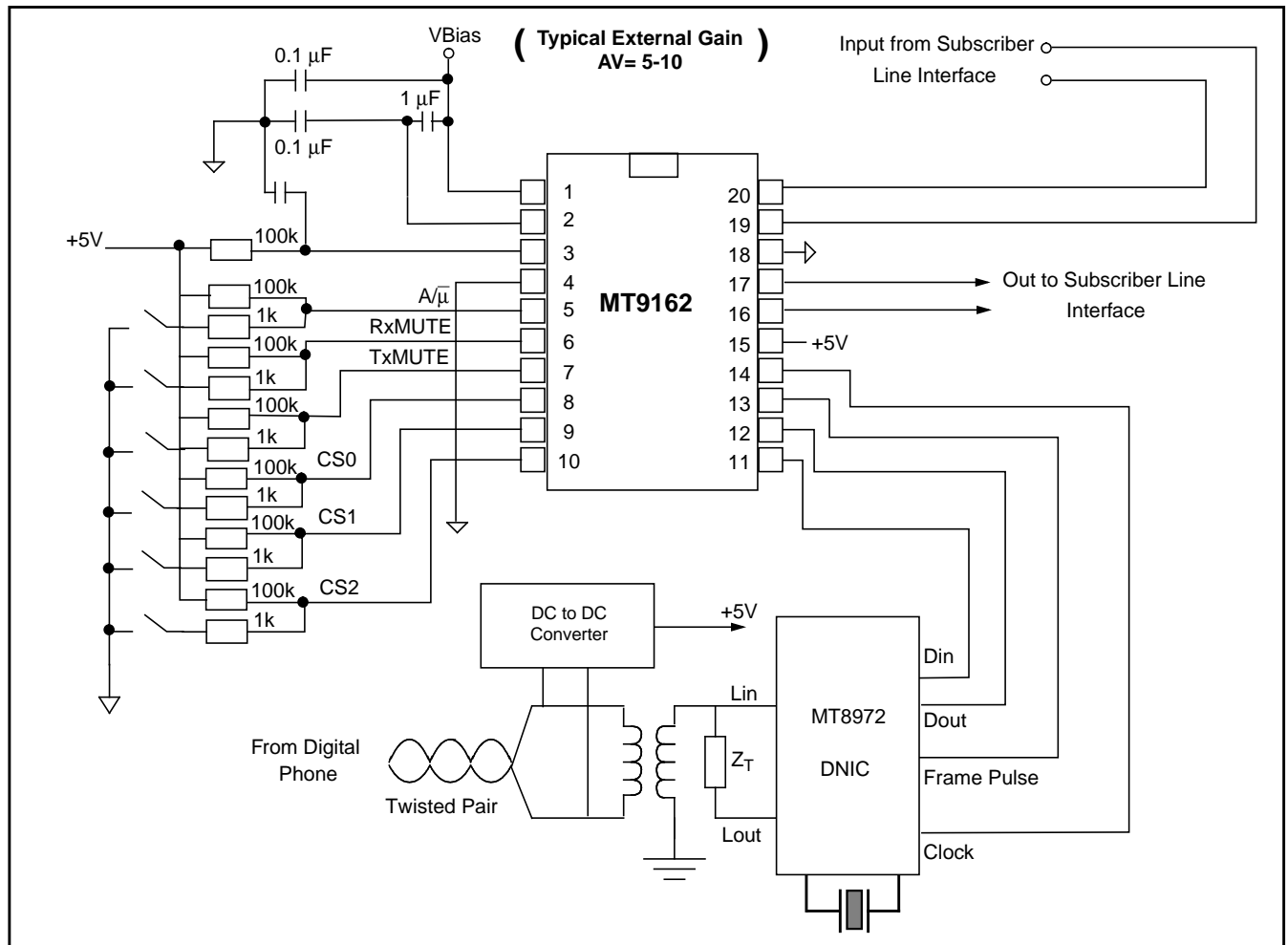


Figure 4 - Line Card Application

**Absolute Maximum Ratings<sup>†</sup>**

	Parameter	Symbol	Min	Max	Units
1	Supply Voltage	$V_{DD} - V_{SS}$	- 0.3	7	V
2	Voltage on any I/O pin	$V_I/V_O$	$V_{SS} - 0.3$	$V_{DD} + 0.3$	V
3	Current on any I/O pin (transducers excluded)	$I_I/I_O$		$\pm 20$	mA
4	Storage Temperature	$T_S$	- 65	+ 150	°C
5	Power Dissipation (package)	$P_D$		750	mW

<sup>†</sup> Exceeding these values may cause permanent damage. Functional operation under these conditions is not implied.

**Recommended Operating Conditions** - Voltages are with respect to  $V_{SS}$  unless otherwise stated

	Characteristics	Sym	Min	Typ	Max	Units	Test Conditions
1	Supply Voltage	$V_{DD}$	4.75	5	5.25	V	
2	CMOS Input Voltage (high)	$V_{IHC}$	4.5		$V_{DD}$	V	
3	CMOS Input Voltage (low)	$V_{ILC}$	$V_{SS}$		0.5	V	
4	Operating Temperature	$T_A$	- 40		+ 85	°C	

**Power Characteristics**

	Characteristics	Sym	Min	Typ	Max	Units	Test Conditions
1	Static Supply Current (clock disabled)	$I_{DDC1}$		4	20	$\mu$ A	Outputs unloaded, Input signals static, not loaded
2	Dynamic Supply Current: Total all functions enabled	$I_{DDFT}$		7.0	10	mA	See Note 1

Note 1: Power delivered to the load is in addition to the bias current requirements.

**DC Electrical Characteristics**<sup>†</sup> - Voltages are with respect to ground ( $V_{SS}$ ) unless otherwise stated.

	Characteristics	Sym	Min	Typ <sup>‡</sup>	Max	Units	Test Conditions
1	Input HIGH Voltage CMOS inputs	$V_{IHC}$	3.5			V	
2	Input LOW Voltage CMOS inputs	$V_{ILC}$			1.5	V	
3	VBias Voltage Output	$V_{Bias}$		$V_{DD}/2$		V	Max. Load = 10k $\Omega$
4	$V_{Ref}$ Output Voltage	$V_{Ref}$		$V_{DD}/2-1.9$		V	No load
5	Input Leakage Current	$I_{IZ}$		0.1	10	$\mu$ A	$V_{IN}=V_{DD}$ to $V_{SS}$
6	Positive Going Threshold Voltage (PWRST only) Negative Going Threshold Voltage (PWRST only)	$V_{T+}$ $V_{T-}$	3.7		1.3	V V	
7	Output HIGH Current	$I_{OH}$	3	7		mA	$V_{OH} = 0.9*V_{DD}$ See Note 1
8	Output LOW Current	$I_{OL}$	5	10		mA	$V_{OL} = 0.1*V_{DD}$ See Note 1
9	Output Leakage Current	$I_{OZ}$		0.01	10	$\mu$ A	$V_{OUT} = V_{DD}$ and $V_{SS}$
10	Output Capacitance	$C_o$		15		pF	
11	Input Capacitance	$C_i$		10		pF	

<sup>†</sup> DC Electrical Characteristics are over recommended temperature range & recommended power supply voltages.

<sup>‡</sup> Typical figures are at 25 °C and are for design aid only: not guaranteed and not subject to production testing.

\* Note 1 - Magnitude measurement, ignore signs.

**Clockin Tolerance Characteristics**<sup>†</sup>

	Characteristics	Min	Typ <sup>‡</sup>	Max	Units	Test Conditions
1	CLOCKin Frequency (Asynchronous Mode)	4095.6	4096	4096.4	kHz	(i.e., 100 ppm)

<sup>†</sup> AC Electrical Characteristics are over recommended temperature range & recommended power supply voltages.

<sup>‡</sup> Typical figures are at 25 °C and are for design aid only: not guaranteed and not subject to production testing.

**AC Characteristics<sup>†</sup> for A/D (Transmit) Path** -  $0\text{dBm0} = A_{\text{Lo}3.17} - 3.17\text{dB} = 1.773V_{\text{rms}}$  for  $\mu$ -Law and  $0\text{dBm0} = A_{\text{Lo}3.14} - 3.14\text{dB} = 1.843V_{\text{rms}}$  for A-Law, at the Codec. ( $V_{\text{Ref}}=0.6$  volts and  $V_{\text{Bias}}=2.5$  volts.)

	Characteristics	Sym	Min	Typ <sup>‡</sup>	Max	Units	Test Conditions
1	Analog input equivalent to overload decision	$A_{\text{Li}3.17}$ $A_{\text{Li}3.14}$		7.334 7.6		Vp-p Vp-p	$\mu$ -Law A-Law Both at Codec
2	Absolute half-channel gain AIN $\pm$ to Dout	$G_{\text{AX}1}$	5.2	6.0	6.8	dB	Transmit filter gain=0dB setting. @1020Hz
3	Gain tracking vs. input level ITU-T G.714 Method 2	$G_{\text{TX}}$	-0.3 -0.6 -1.6		0.3 0.6 1.6	dB dB dB	3 to -40 dBm0 -40 to -50 dBm0 -50 to -55 dBm0
4	Signal to total Distortion vs. input level. ITU-T G.714 Method 2	$D_{\text{QX}}$	35 29 24			dB dB dB	0 to -30 dBm0 -40 dBm0 -45 dBm0
5	Transmit Idle Channel Noise	$N_{\text{CX}}$ $N_{\text{PX}}$		8.5 -71	12 -69	dBrnC0 dBm0p	$\mu$ -Law A-Law
6	Gain relative to gain at <50Hz 60Hz 200Hz 300 - 3000 Hz 3000 - 3400 Hz 4000 Hz >4600 Hz	$G_{\text{RX}}$		-45 -0.25 -0.9 -23 -40	-25 -30 0.0 0.25 0.25 -12.5 -25	dB dB dB dB dB dB dB	
7	Absolute Delay	$D_{\text{AX}}$		360		$\mu$ s	at frequency of minimum delay
8	Group Delay relative to $D_{\text{AX}}$	$D_{\text{DX}}$		750 380 130 750		$\mu$ s $\mu$ s $\mu$ s $\mu$ s	500-600 Hz 600 - 1000 Hz 1000 - 2600 Hz 2600 - 2800 Hz
9	Power Supply Rejection  f=1020 Hz f=0.3 to 3 kHz f=3 to 4 kHz f=4 to 50 kHz	PSSR PSSR1 PSSR2 PSSR3	37	37 40 35 40		dB dB dB dB	$\pm 100\text{mV}$ peak signal on $V_{\text{DD}}$ $\mu$ -law PSSR1-3 not production tested

<sup>†</sup> AC Electrical Characteristics are over recommended temperature range & recommended power supply voltages.

<sup>‡</sup> Typical figures are at 25 °C and are for design aid only: not guaranteed and not subject to production testing.



**AC Characteristics<sup>†</sup> for D/A (Receive) Path** -  $0\text{dBm0} = A_{\text{Lo3.17}} - 3.17\text{dB} = 1.773V_{\text{rms}}$  for  $\mu$ -Law and  $0\text{dBm0} = A_{\text{Lo3.14}} - 3.14\text{dB} = 1.843V_{\text{rms}}$  for A-Law, at the Codec. ( $V_{\text{Ref}}=0.6$  volts and  $V_{\text{Bias}}=2.5$  volts.)

	Characteristics	Sym	Min	Typ <sup>‡</sup>	Max	Units	Test Conditions
1	Analog output at the Codec full scale	$A_{\text{Lo3.17}}$ $A_{\text{Lo3.14}}$		7.225 7.481		Vp-p Vp-p	$\mu$ -Law A-Law
2	Absolute half-channel gain. Din to AOOUT $\pm$	$G_{\text{AR1}}$	-0.8	0	0.8	dB	@1020Hz
3	Gain tracking vs. input level ITU-T G.714 Method 2	$G_{\text{TR}}$	-0.3 -0.6 -1.6		0.3 0.6 1.6	dB dB dB	3 to -40 dBm0 -40 to -50 dBm0 -50 to -55 dBm0
4	Signal to total distortion vs. input level. ITU-T G.714 Method 2	$G_{\text{QR}}$	35 29 24			dB dB dB	0 to -30 dBm0 -40 dBm0 -45 dBm0
5	Receive Idle Channel Noise	$N_{\text{CR}}$ $N_{\text{PR}}$		7 -84	10 -80	dBrnC0 dBm0p	$\mu$ -Law A-Law
6	Gain relative to gain at 1020Hz 200Hz 300 - 3000 Hz 3000 - 3400 Hz 4000 Hz >4600 Hz	$G_{\text{RR}}$	-0.25 -0.90		0.25 0.25 0.25 -12.5 -25	dB dB dB dB dB	
7	Absolute Delay	$D_{\text{AR}}$		240		$\mu$ s	at frequency of min. delay
8	Group Delay relative to $D_{\text{AR}}$	$D_{\text{DR}}$		750 380 130 750		$\mu$ s $\mu$ s $\mu$ s $\mu$ s	500-600 Hz 600 - 1000 Hz 1000 - 2600 Hz 2600 - 2800 Hz
9	Crosstalk D/A to A/D A/D to D/A	$CT_{\text{RT}}$ $CT_{\text{TR}}$			-74 -80	dB dB	G.714.16 ITU-T

<sup>†</sup> AC Electrical Characteristics are over recommended temperature range & recommended power supply voltages.

<sup>‡</sup> Typical figures are at 25 °C and are for design aid only: not guaranteed and not subject to production testing.

### Electrical Characteristics<sup>†</sup> for Analog Outputs

	Characteristics	Sym	Min	Typ <sup>‡</sup>	Max	Units	Test Conditions
1	Load impedance at Output	$E_{\text{ZL}}$	20k			ohms	across AOOUT $\pm$
2	Allowable output capacitive load	$E_{\text{CL}}$		20		pF	each pin: AOOUT+, AOOUT-
3	Analog output harmonic distortion	$E_{\text{D}}$			0.5	%	20k ohms load across AOOUT $\pm$ $V_{\text{O}} \leq 693\text{mV}_{\text{RMS}}$

<sup>†</sup> Electrical Characteristics are over recommended temperature range & recommended power supply voltages.

<sup>‡</sup> Typical figures are at 25 °C and are for design aid only: not guaranteed and not subject to production testing.

Electrical Characteristics<sup>†</sup> for Analog Inputs

	Characteristics	Sym	Min	Typ <sup>‡</sup>	Max	Units	Test Conditions
1	Maximum input voltage without overloading Codec across AIN+/AIN-	$V_{IOLH}$		2.90 3.00		Vp-p	$A/\mu = 0$ $A/\mu = 1$
2	Input Impedance	$Z_I$	50			k $\Omega$	AIN+/AIN- to $V_{SS}$

<sup>†</sup> Electrical Characteristics are over recommended temperature range & recommended power supply voltages.

<sup>‡</sup> Typical figures are at 25 °C and are for design aid only: not guaranteed and not subject to production testing.

AC Electrical Characteristics<sup>†</sup> - SSI BUS Synchronous Timing (see Figure 5)

	Characteristics	Sym	Min	Typ <sup>‡</sup>	Max	Units	Test Conditions
1	BCL Clock Period	$t_{BCL}$	244		1953	ns	BCL=4096 kHz to 512 kHz
2	BCL Pulse Width High	$t_{BCLH}$		122		ns	BCL=4096 kHz
3	BCL Pulse Width Low	$t_{BCLL}$		122		ns	BCL=4096 kHz
4	BCL Rise/Fall Time	$t_R/t_F$		20		ns	Note 1
5	Strobe Pulse Width	$t_{ENW}$		$8 \times t_{BCL}$		ns	Note 1
6	Strobe setup time before BCL falling	$t_{SSS}$	70		$t_{BCL-80}$	ns	
7	Strobe hold time after BCL falling	$t_{SSH}$	80		$t_{BCL-80}$	ns	
8	Dout High Impedance to Active Low from Strobe rising	$t_{DOZL}$			50	ns	$C_L=150$ pF, $R_L=1K$
9	Dout High Impedance to Active High from Strobe rising	$t_{DOZH}$			50	ns	$C_L=150$ pF, $R_L=1K$
10	Dout Active Low to High Impedance from Strobe falling	$t_{DOLZ}$			50	ns	$C_L=150$ pF, $R_L=1K$
11	Dout Active High to High Impedance from Strobe falling	$t_{DOHZ}$			50	ns	$C_L=150$ pF, $R_L=1K$
12	Dout Delay (high and low) from BCL rising	$t_{DD}$			50	ns	$C_L=150$ pF, $R_L=1K$
13	Din Setup time before BCL falling	$t_{DIS}$	20			ns	
14	Din Hold Time from BCL falling	$t_{DIH}$	50			ns	

<sup>†</sup> Timing is over recommended temperature range & recommended power supply voltages.

<sup>‡</sup> Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

NOTE 1: Not production tested, guaranteed by design.

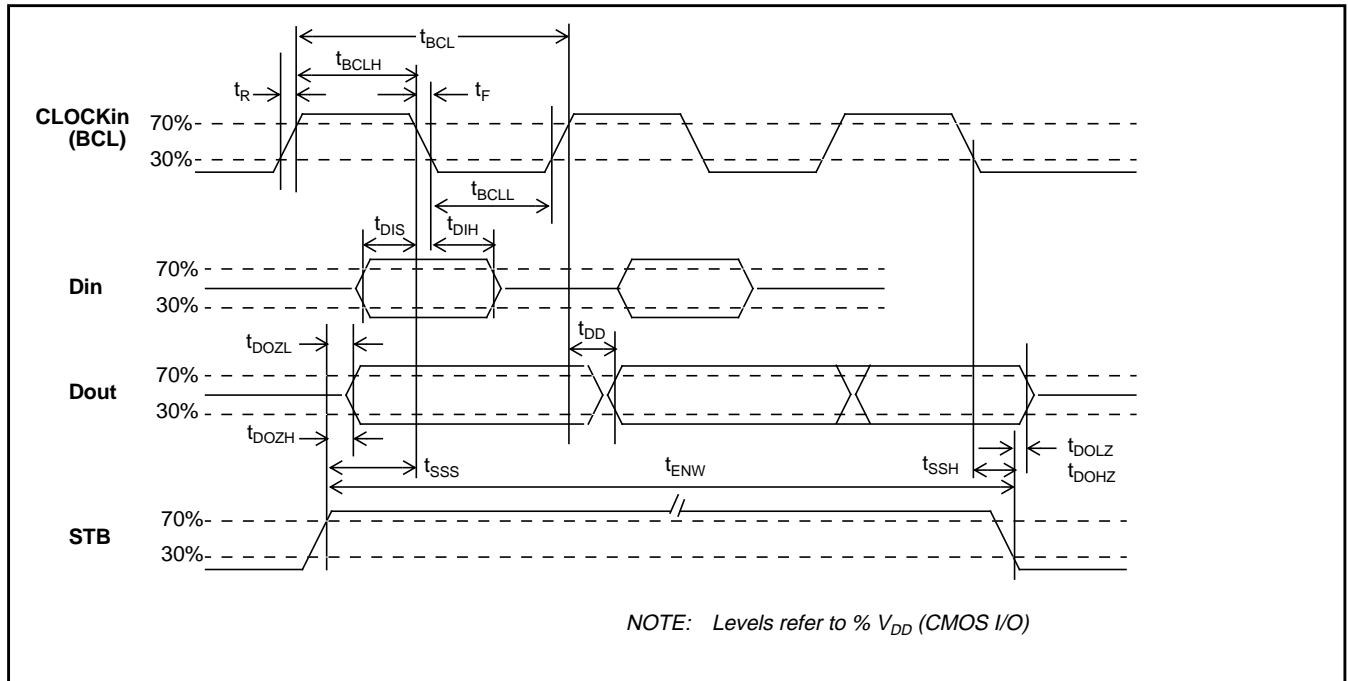


Figure 5 - SSI Synchronous Timing Diagram

AC Electrical Characteristics<sup>†</sup> - SSI BUS Asynchronous Timing (note 1) (see Figure 6)

	Characteristics	Sym	Min	Typ <sup>‡</sup>	Max	Units	Test Conditions
1	Bit Cell Period	$T_{DATA}$		7812 3906		ns ns	BCL=128 kHz BCL=256 kHz
2	Frame Jitter	$T_j$			600	ns	
3	Bit 1 Dout Delay from STB going high	$t_{dda1}$			$T_j+600$	ns	$C_L=150$ pF, $R_L=1K$
4	Bit 2 Dout Delay from STB going high	$t_{dda2}$	600+	600+	600 + $T_{DATA}+T_j$	ns	$C_L=150$ pF, $R_L=1K$
5	Bit n Dout Delay from STB going high	$t_{ddan}$	600 + $(n-1) \times$ $T_{DATA}-T_j$	600 + $(n-1) \times$ $T_{DATA}$	600 + $(n-1) \times$ $T_{DATA}+T_j$	ns	$C_L=150$ pF, $R_L=1K$ $n=3$ to 8
6	Bit 1 Data Boundary	$T_{DATA1}$	$T_{DATA}-T_j$		$T_{DATA}+T_j$	ns	
7	Din Bit n Data Setup time from STB rising	$t_{SU}$	$T_{DATA}\sqrt{2}$ +500ns- $T_j$ + $(n-1) \times$ $T_{DATA}$			ns	$n=1-8$
8	Din Data Hold time from STB rising	$t_{ho}$	$T_{DATA}\sqrt{2}$ +500ns+ $T_j$ + $(n-1) \times$ $T_{DATA}$			ns	

<sup>†</sup> Timing is over recommended temperature range & recommended power supply voltages.

<sup>‡</sup> Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

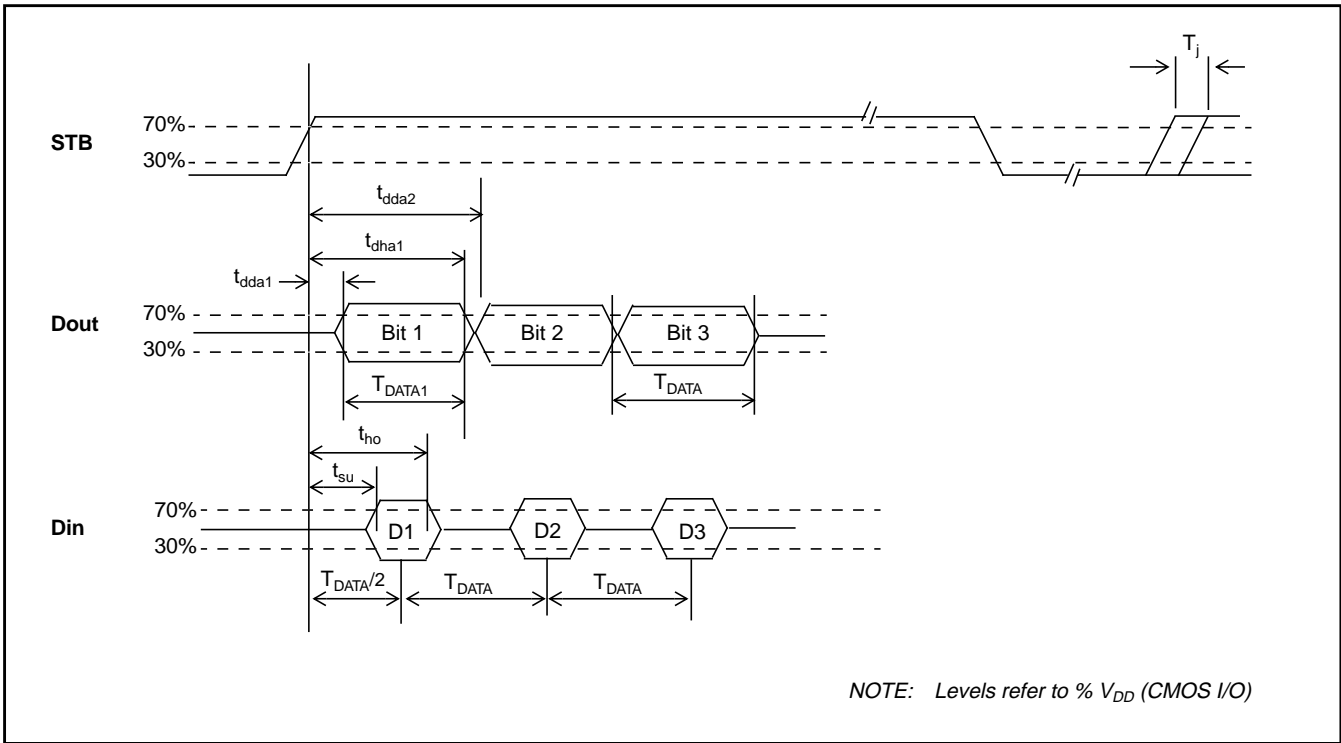
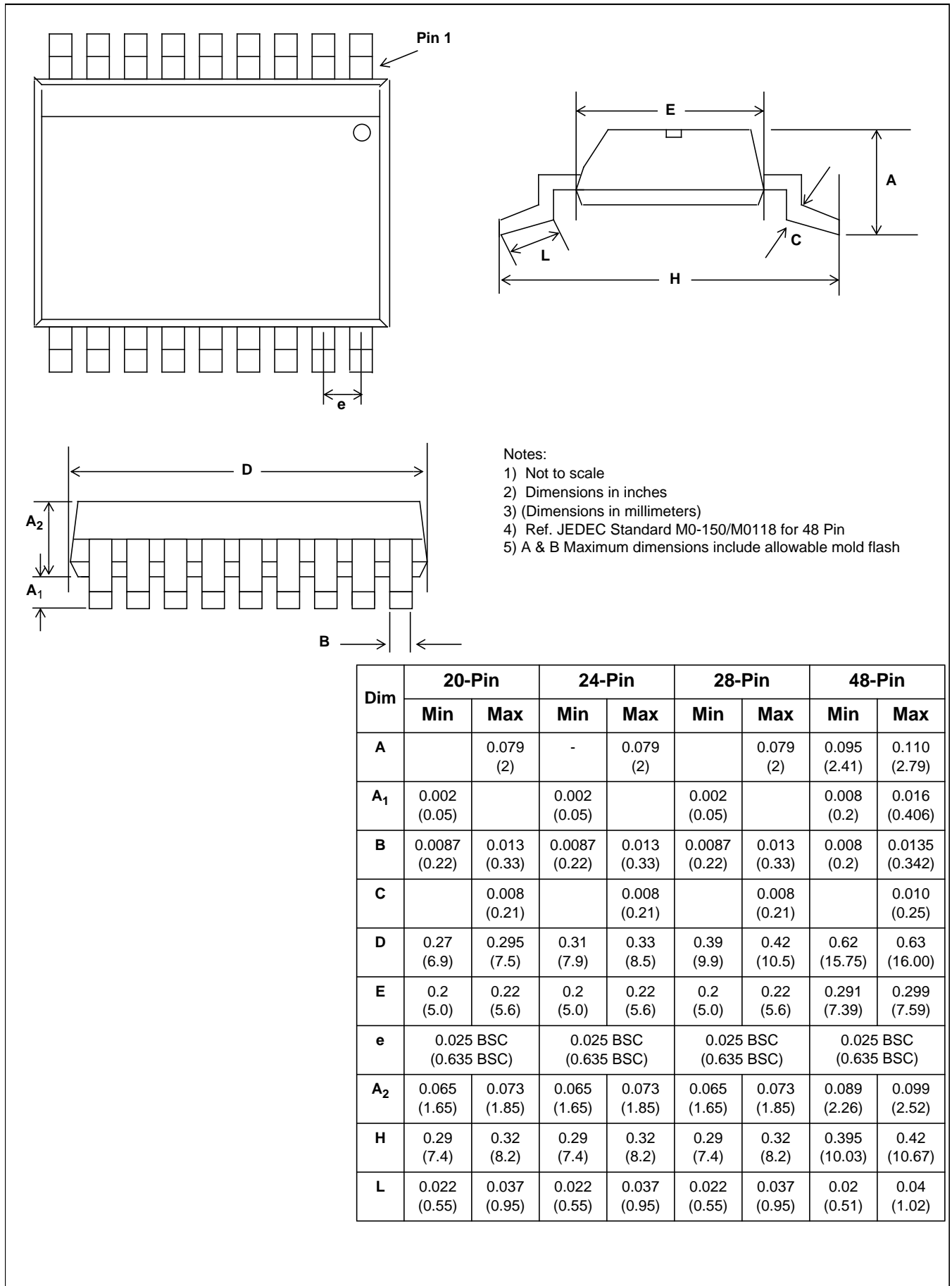
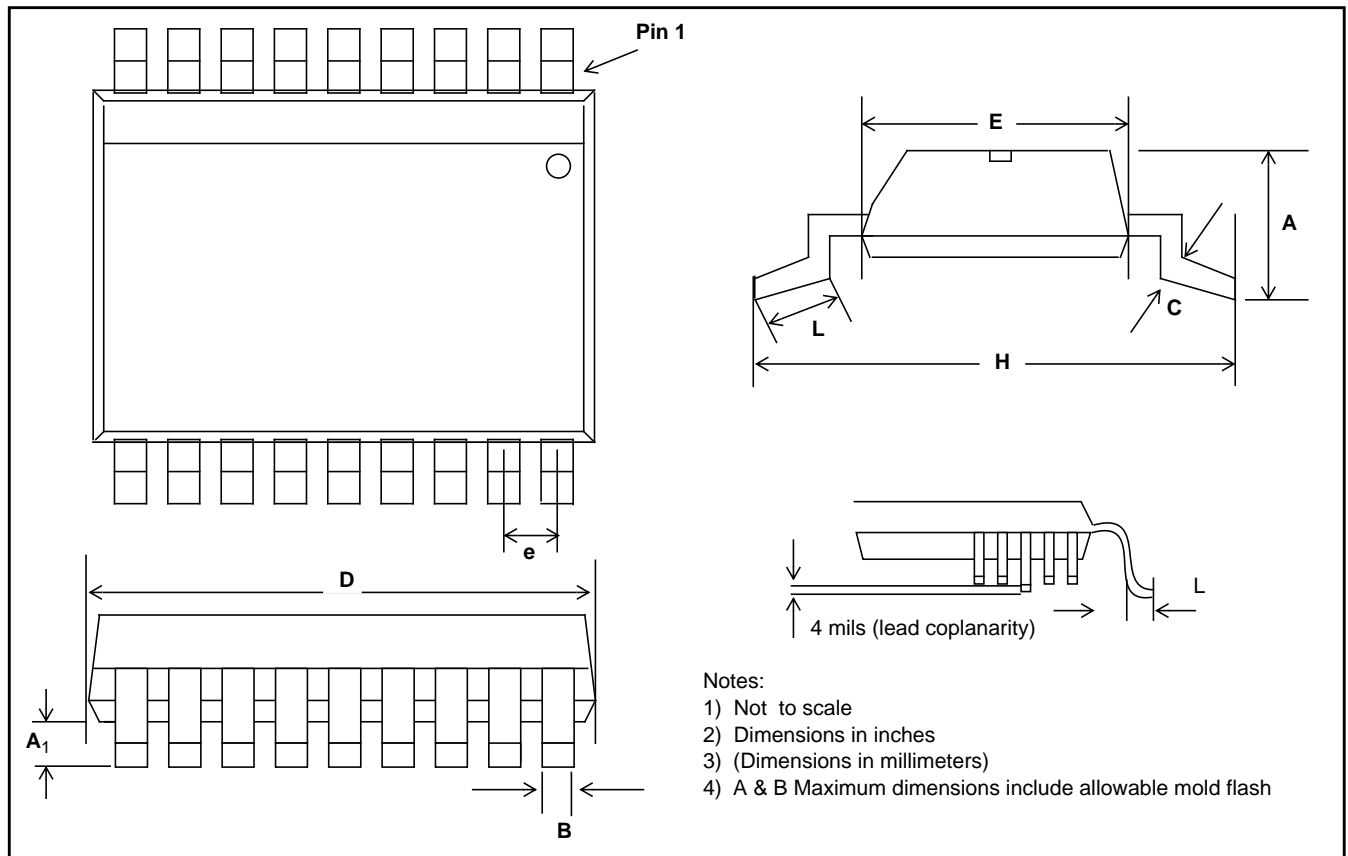


Figure 6 - SSI Asynchronous Timing Diagram



Dim	20-Pin		24-Pin		28-Pin		48-Pin	
	Min	Max	Min	Max	Min	Max	Min	Max
A		0.079 (2)	-	0.079 (2)		0.079 (2)	0.095 (2.41)	0.110 (2.79)
A <sub>1</sub>	0.002 (0.05)		0.002 (0.05)		0.002 (0.05)		0.008 (0.2)	0.016 (0.406)
B	0.0087 (0.22)	0.013 (0.33)	0.0087 (0.22)	0.013 (0.33)	0.0087 (0.22)	0.013 (0.33)	0.008 (0.2)	0.0135 (0.342)
C		0.008 (0.21)		0.008 (0.21)		0.008 (0.21)		0.010 (0.25)
D	0.27 (6.9)	0.295 (7.5)	0.31 (7.9)	0.33 (8.5)	0.39 (9.9)	0.42 (10.5)	0.62 (15.75)	0.63 (16.00)
E	0.2 (5.0)	0.22 (5.6)	0.2 (5.0)	0.22 (5.6)	0.2 (5.0)	0.22 (5.6)	0.291 (7.39)	0.299 (7.59)
e	0.025 BSC (0.635 BSC)		0.025 BSC (0.635 BSC)		0.025 BSC (0.635 BSC)		0.025 BSC (0.635 BSC)	
A <sub>2</sub>	0.065 (1.65)	0.073 (1.85)	0.065 (1.65)	0.073 (1.85)	0.065 (1.65)	0.073 (1.85)	0.089 (2.26)	0.099 (2.52)
H	0.29 (7.4)	0.32 (8.2)	0.29 (7.4)	0.32 (8.2)	0.29 (7.4)	0.32 (8.2)	0.395 (10.03)	0.42 (10.67)
L	0.022 (0.55)	0.037 (0.95)	0.022 (0.55)	0.037 (0.95)	0.022 (0.55)	0.037 (0.95)	0.02 (0.51)	0.04 (1.02)

Small Shrink Outline Package (SSOP) - N Suffix

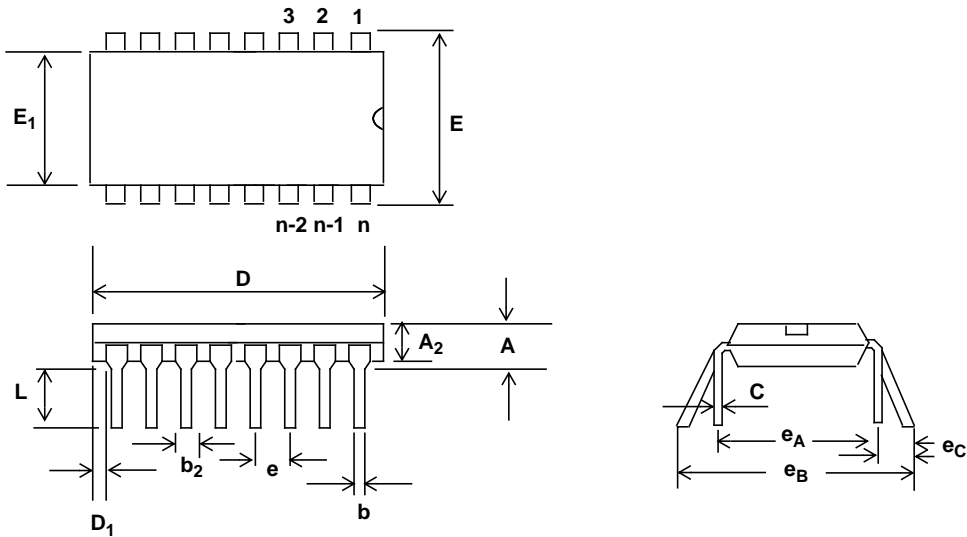


DIM	16-Pin		18-Pin		20-Pin		24-Pin		28-Pin	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
A	0.093 (2.35)	0.104 (2.65)	0.093 (2.35)	0.104 (2.65)	0.093 (2.35)	0.104 (2.65)	0.093 (2.35)	0.104 (2.65)	0.093 (2.35)	0.104 (2.65)
A <sub>1</sub>	0.004 (0.10)	0.012 (0.30)	0.004 (0.10)	0.012 (0.30)	0.004 (0.10)	0.012 (0.30)	0.004 (0.10)	0.012 (0.30)	0.004 (0.10)	0.012 (0.30)
B	0.013 (0.33)	0.020 (0.51)	0.013 (0.33)	0.030 (0.51)	0.013 (0.33)	0.020 (0.51)	0.013 (0.33)	0.020 (0.51)	0.013 (0.33)	0.020 (0.51)
C	0.009 (0.231)	0.013 (0.318)	0.009 (0.231)	0.013 (0.318)	0.009 (0.231)	0.013 (0.318)	0.009 (0.231)	0.013 (0.318)	0.009 (0.231)	0.013 (0.318)
D	0.398 (10.1)	0.413 (10.5)	0.447 (11.35)	0.4625 (11.75)	0.496 (12.60)	0.512 (13.00)	0.5985 (15.2)	0.614 (15.6)	0.697 (17.7)	0.7125 (18.1)
E	0.291 (7.40)	0.299 (7.40)	0.291 (7.40)	0.299 (7.40)	0.291 (7.40)	0.299 (7.40)	0.291 (7.40)	0.299 (7.40)	0.291 (7.40)	0.299 (7.40)
e	0.050 BSC (1.27 BSC)		0.050 BSC (1.27 BSC)		0.050 BSC (1.27 BSC)		0.050 BSC (1.27 BSC)		0.050 BSC (1.27 BSC)	
H	0.394 (10.00)	0.419 (10.65)	0.394 (10.00)	0.419 (10.65)	0.394 (10.00)	0.419 (10.65)	0.394 (10.00)	0.419 (10.65)	0.394 (10.00)	0.419 (10.65)
L	0.016 (0.40)	0.050 (1.27)	0.016 (0.40)	0.050 (1.27)	0.016 (0.40)	0.050 (1.27)	0.016 (0.40)	0.050 (1.27)	0.016 (0.40)	0.050 (1.27)

**Lead SOIC Package - S Suffix**

NOTES: 1. Controlling dimensions in parenthesis ( ) are in millimeters.  
2. Converted inch dimensions are not necessarily exact.

# Package Outlines

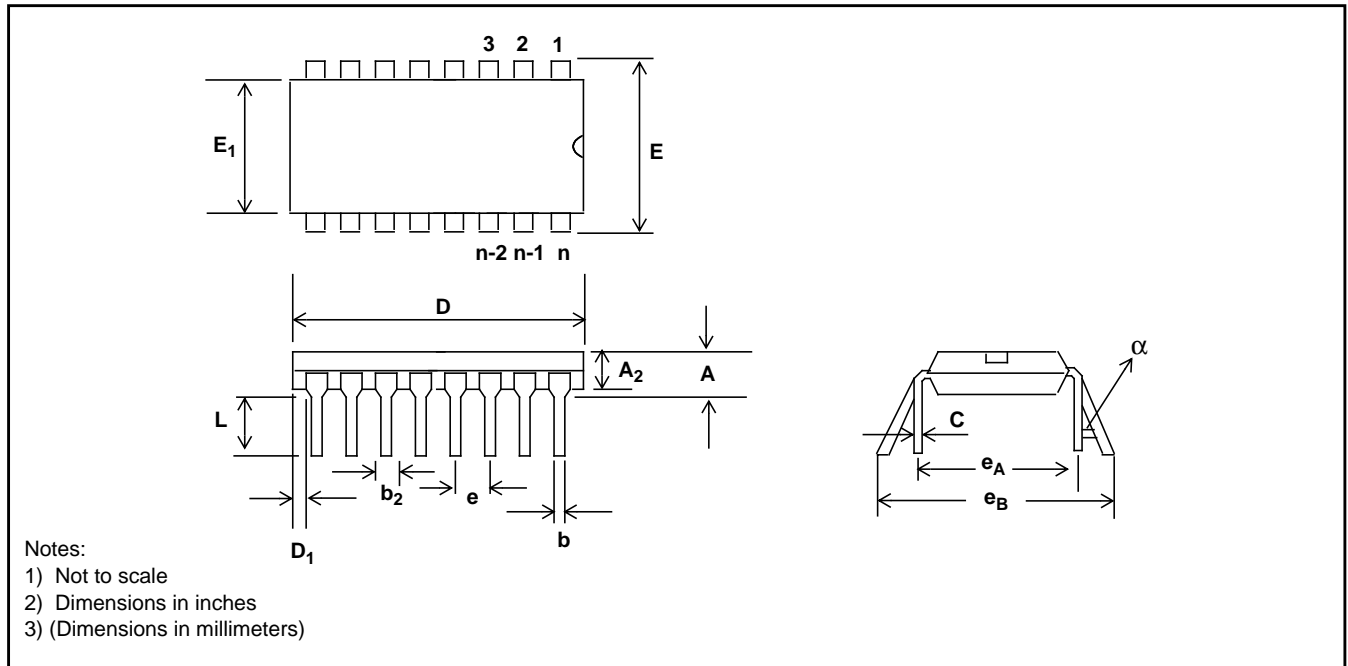


- Notes:
- 1) Not to scale
  - 2) Dimensions in inches
  - 3) (Dimensions in millimeters)

**Plastic Dual-In-Line Packages (PDIP) - E Suffix**

DIM	8-Pin		16-Pin		18-Pin		20-Pin	
	Plastic		Plastic		Plastic		Plastic	
	Min	Max	Min	Max	Min	Max	Min	Max
<b>A</b>		0.210 (5.33)		0.210 (5.33)		0.210 (5.33)		0.210 (5.33)
<b>A<sub>2</sub></b>	0.115 (2.92)	0.195 (4.95)	0.115 (2.92)	0.195 (4.95)	0.115 (2.92)	0.195 (4.95)	0.115 (2.92)	0.195 (4.95)
<b>b</b>	0.014 (0.356)	0.022 (0.558)	0.014 (0.356)	0.022 (0.558)	0.014 (0.356)	0.022 (0.558)	0.014 (0.356)	0.022 (0.558)
<b>b<sub>2</sub></b>	0.045 (1.14)	0.070 (1.77)	0.045 (1.14)	0.070 (1.77)	0.045 (1.14)	0.070 (1.77)	0.045 (1.14)	0.070 (1.77)
<b>C</b>	0.008 (0.203)	0.014 (0.356)	0.008 (0.203)	0.014 (0.356)	0.008 (0.203)	0.014 (0.356)	0.008 (0.203)	0.014 (0.356)
<b>D</b>	0.355 (9.02)	0.400 (10.16)	0.780 (19.81)	0.800 (20.32)	0.880 (22.35)	0.920 (23.37)	0.980 (24.89)	1.060 (26.9)
<b>D<sub>1</sub></b>	0.005 (0.13)		0.005 (0.13)		0.005 (0.13)		0.005 (0.13)	
<b>E</b>	0.300 (7.62)	0.325 (8.26)	0.300 (7.62)	0.325 (8.26)	0.300 (7.62)	0.325 (8.26)	0.300 (7.62)	0.325 (8.26)
<b>E<sub>1</sub></b>	0.240 (6.10)	0.280 (7.11)	0.240 (6.10)	0.280 (7.11)	0.240 (6.10)	0.280 (7.11)	0.240 (6.10)	0.280 (7.11)
<b>e</b>	0.100 BSC (2.54)		0.100 BSC (2.54)		0.100 BSC (2.54)		0.100 BSC (2.54)	
<b>e<sub>A</sub></b>	0.300 BSC (7.62)		0.300 BSC (7.62)		0.300 BSC (7.62)		0.300 BSC (7.62)	
<b>L</b>	0.115 (2.92)	0.150 (3.81)	0.115 (2.92)	0.150 (3.81)	0.115 (2.92)	0.150 (3.81)	0.115 (2.92)	0.150 (3.81)
<b>e<sub>B</sub></b>		0.430 (10.92)		0.430 (10.92)		0.430 (10.92)		0.430 (10.92)
<b>e<sub>C</sub></b>	0	0.060 (1.52)	0	0.060 (1.52)	0	0.060 (1.52)	0	0.060 (1.52)

**NOTE: Controlling dimensions in parenthesis ( ) are in millimeters.**



**Plastic Dual-In-Line Packages (PDIP) - E Suffix**

DIM	22-Pin		24-Pin		28-Pin		40-Pin	
	Plastic		Plastic		Plastic		Plastic	
	Min	Max	Min	Max	Min	Max	Min	Max
<b>A</b>		0.210 (5.33)		0.250 (6.35)		0.250 (6.35)		0.250 (6.35)
<b>A<sub>2</sub></b>	0.125 (3.18)	0.195 (4.95)	0.125 (3.18)	0.195 (4.95)	0.125 (3.18)	0.195 (4.95)	0.125 (3.18)	0.195 (4.95)
<b>b</b>	0.014 (0.356)	0.022 (0.558)	0.014 (0.356)	0.022 (0.558)	0.014 (0.356)	0.022 (0.558)	0.014 (0.356)	0.022 (0.558)
<b>b<sub>2</sub></b>	0.045 (1.15)	0.070 (1.77)	0.030 (0.77)	0.070 (1.77)	0.030 (0.77)	0.070 (1.77)	0.030 (0.77)	0.070 (1.77)
<b>C</b>	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.015 (0.381)	0.008 (0.204)	0.015 (0.381)
<b>D</b>	1.050 (26.67)	1.120 (28.44)	1.150 (29.3)	1.290 (32.7)	1.380 (35.1)	1.565 (39.7)	1.980 (50.3)	2.095 (53.2)
<b>D<sub>1</sub></b>	0.005 (0.13)		0.005 (0.13)		0.005 (0.13)		0.005 (0.13)	
<b>E</b>	0.390 (9.91)	0.430 (10.92)	0.600 (15.24)	0.670 (17.02)	0.600 (15.24)	0.670 (17.02)	0.600 (15.24)	0.670 (17.02)
<b>E</b>			0.290 (7.37)	.330 (8.38)				
<b>E<sub>1</sub></b>	0.330 (8.39)	0.380 (9.65)	0.485 (12.32)	0.580 (14.73)	0.485 (12.32)	0.580 (14.73)	0.485 (12.32)	0.580 (14.73)
<b>E<sub>1</sub></b>			0.246 (6.25)	0.254 (6.45)				
<b>e</b>	0.100 BSC (2.54)		0.100 BSC (2.54)		0.100 BSC (2.54)		0.100 BSC (2.54)	
<b>e<sub>A</sub></b>	0.400 BSC (10.16)		0.600 BSC (15.24)		0.600 BSC (15.24)		0.600 BSC (15.24)	
<b>e<sub>A</sub></b>			0.300 BSC (7.62)					
<b>e<sub>B</sub></b>				0.430 (10.92)				
<b>L</b>	0.115 (2.93)	0.160 (4.06)	0.115 (2.93)	0.200 (5.08)	0.115 (2.93)	0.200 (5.08)	0.115 (2.93)	0.200 (5.08)
<b>α</b>		15°		15°		15°		15°

Shaded areas for 300 Mil Body Width 24 PDIP only





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